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AUTHOR Reddix, Michael D.; Dunn, Bruce R.
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ABSTRACT

Differences in metaphor recall from poetry were investigated using 10 female and 10 male college student subjects hypothesized as having either an analytic or a holistic processing style. Style was determined using bilateral alpha (8-13Hz) scores measured from the cerebral cortex. It was suggested, on the basis of bimodal theory, that holistic processors would produce greater amounts of EEG alpha and recall more metaphor from less logically stuctured poetry than would analytic processors. Recall of metaphor by analytic and holistic males provided partial support for bimodal theory, with holistic processors consistently recalling more metaphor from less logically stuctured poetry, and analytic processors recalling more metaphor from tightly structured poetry. Analytic and holistic females' metaphor recall patterns were generally opposite to those of males. EEG alpha supported the existence of the holistic processing dimension derived from bimodal theory. As predicted, alpha production of holistic processors was greater than that of analytic processors during poetry encoding. (Author/FL)

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CENTER FOR THE STUDY OF READING

Technical Report No. 324

# EEG ALPHA PRODUCTION CORRELATES OF COGNITIVE STYLE DIFFERENCES AND RECALL OF METAPHOR FROM POETRY

Michael D. Reddix
University of Illinois at Urbana-Champaign

Bruce R. Dunn
The University of West Florida

September 1984

University of Illinois
at Urbana-Champaign
51 Gerty Drive
Champaign, Illinois 61820

Bolt Beranek and Newman Inc.
10 Moulton Street
Cambridge, Massachusetts 02238

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Abstract

Differences in metaphor recall from poetry were investigated using subjects hypothesized as having either an analytic or holistic processing style. Style was determined using bilateral alpha (8-13 Hz) scores measured from the cerebral cortex. It was suggested, on the basis of bimodal theory, that holistic processors when compared to analytic processors would produce greater amounts of EEG alpha and recall more metaphor from less logically structured poetry. Recall of metaphor by analytic and holistic males provided partial support for bimodal theory. Holistics consistently recalled more metaphor from less logically structured poetry, while analytics recalled more metaphor from tightly structured poetry. Analytic and holistic females' metaphor recall patterns were generally opposite that of analytic and holistic males. EEG alpha supported the existence of the holistic processing dimension derived from bimodal theory. As predicted, alpha production of holistics was greater than that of analytics during poetry encoding.

EEG Alpha Production Correlates of Cognitive Style Differences and Recall of Metaphor from Poetry

In a recent study Dunn, Gould, and Singer (1981) used alpha activity and free recall measurements to investigate a dimension of cognitive style derived from the bimodal theory of cognitive processing (Deikman, 1971, 1976; Dunn, in press; Ornstein, 1973, 1977). Bimodal theory argues that the form of information contained in long-term memory is strongly influenced by the type or mode of conscious processing, analytic or holistic, used in encoding the information. The analytic mode of processing is predominantly logical and sequential, while the holistic mode of information processing is intuitive and simultaneous (parallel).

Deikman (1971, 1976) argues that when people are in the analytic mode of conscious processing they produce less alpha than they do when in a holistic mode of conscious processing. Dunn et al. (1981) tested the notions of Deikman (1971, 1976) and demonstrated that power in the alpha bandwidth is a reliable physiological correlate of one's cognitive style. Dunn et al. (1981) point out that, at the time of their study, no research had provided support (using a holistic task) for the existence of a truly holistic cognitive style. Consequently, they based their hypotheses and findings on an analytic continuum. Analytic and holistic processing styles (as suggested by bimodal theory) were

represented on a high-to-low analytic scale. High analytic processors (analytics) were defined as those who produced relatively less bilateral alpha during resting baseline EEG recordings. Low analytics (holistics) produced relatively more bilateral alpha. For the purposes of this study the terms analytic and holistic will be used.

Using Meyer's (1975) content-structure grammar, Dunn et al. (1981) found that analytic processors recalled more superordinate than subordinate information from highly structured expository text. These same individuals also encoded and recalled that information using a different and more logical pattern than did holistics. Analytics were also found to produce relatively less alpha during the reading and encoding of highly structured expository text. During reading, more mean alpha was recorded from the left hemisphere than the right. This type of alpha production (left hemisphere greater than right) was consistently observed for both analytics and holistics. When less structured text was used no cognitive style differences were found.

Dunn et al. (1981) suggest the use of narrative text and poetry as stimulus material in order to further test the predictive power of bimodal theory. They argue that if bimodal theory is correct, then holistic subjects should recall relatively more information from narrative text and poetry

relative to analytics. It is important to note that Dunn (in press) and Dunn et al. (1981) do not exclude the existence of a truly holistic cognitive style. They suggest that superior holistic performance on a holistic task, like poetry, would lend support to the existence of a holistic continuum of cognitive processing. The primary purpose of the present study is to extend the work of Dunn et al. (1981) by relating the differential alpha activity of analytic and holistic processors with written recall of two different poetry selections.

## Issues in Hemisphere Dominance

Many investigators (see Dunn, in press for a review) have argued that bimodal processing is hemisphere dependent and that the amount of alpha produced differs reliably between occupational groups (e.g., Doktor & Bloom, 1977). Other research argues against bimodal processing being hemisphere dependent (e.g., Cohen, 1975; White & White, 1975). Based on the latter research as well as other studies (Basso, Bisiach, & Capitani, 1977; Freides, 1977; Hardyck, Tzeng & Wang, 1978; Heeschen & Jurgens, 1977; Levy & Trevarthen, 1976), Dunn et al. (1981) suggest that "analytical and holistic processing styles could best be viewed as unique products caused by different 'mixtures' or interactions of the cerebral hemispheres, rather than separate functions of each" (p. 5).

Goldberg and Costa (1981) also view the cerebral hemispheres as being suited for different dimensions and stages of cognitive processing. Goldberg and Costa (1981) hypothesized that the left hemisphere is superior for unimodal and motor processing and the use of routinized codes or descriptive systems for the processing of specific classes of material familiar to the individual. The right hemisphere is implicated in intermodal integration and the processing of novel stimuli by virtue of its neuroanatomical structure. Due to the wealth of conflicting views regarding hemisphere dominance during cognitive processing associated with different cognitive tasks and stimuli, bilateral alpha production was recorded as a dependent measure of cortical activity for this study.

Issues in Physiological Recordings of Cortical Activity

In order to definitively assess the analytic/holistic dimension of cognitive processing, a major weakness of past EEG research needs to be clarified; namely the failure to adequately study the differences between monopolar and bipolar EEG recordings. It is not clear which type of recording provides the most accurate measure of cortical activity. When an EEG signal is referenced to an active electrode (e.g., Cz; creating a bipolar recording) the recorded difference may not reflect the magnitude of the EEG signal at the recording site of interest. A simplified

example follows: If Cz (reference site) is producing 10 Hz of brain activity and $O_2$ (the site of interest) is producing 13 Hz of brain activity, the differential amplifiers used to record the EEG activity will measure the algebraic difference between the two electrodes (Goff, 1974), e.g., $\pm$ 3 Hz. Consequently, a change in cortical activity at either Cz or $O_2$ will register as a change in evoked activity. If linked ears were used as a reference (creating a monopolar recording), the magnitude of the 13 Hz signal at $O_2$ may be more accurately reflected in the differentially amplified record.

Goff (1974) indicates that a "monopolar recording presumes the existence of an electrode location which is 'inactive' with respect to the evoked neural potentials . . ." (p. 117). Goff, Matsumiya, Allison, and Goff (1969) argue that intersubject variability in evoked potential component distribution increases the variability of bipolar recordings relative to monopolar recordings. As a result, they suggest that bipolar records be interpreted in light of simultaneously recorded monopolar EEG activity. In the present study monopolar and bipolar EEGs were recorded simultaneously while each participant read and encoded poetry.

## Poetry as a Stimulus Material

Poetry was chosen as a stimulus material because it was assumed that it was generally less logical and analytical than expository text and thus might be more easily recalled by holistic processors. Whally (1967) indicated that "poetry fashions itself to the integral mind when the mind seeks to grasp reality as a whole" (p. 131), and, conversely, that technical prose represents the latest and most sophisticated degree of abstraction. Furthermore, Whally (1967) and others (Beaty & Matchett, 1965; Brown & Milstead, 1968; Kreuzer, 1955; Perrin & Ebbitt, 1972) argue that imagery and metaphor are irreducible units in the language of poetry.

In general, poems have the following characteristics: (a) imagery and metaphor central to the theme, (b) greater use of affect (emotion) and concrete word use relative to expository text, (c) periodic structure, and (d) parallelism. If a poem is accurately parametrized by the latter characteristics it will be considered for the purposes of this study to be a holistic form of written language. It is important to note that the central use of metaphor and imagery in poetry may give the reader the ability to understand a description of an instant in time by pulling together (quickly) many disparate ideas, emotions, and sense perceptions (Brown & Milstead, 1968; Whally, 1967). Holistic

poetry will be referred to as descriptive poetry for the remainder of this study. (The reader is referred to Reddix (1983) for a complete development of the characteristics of poetry and the concept of descriptive poetry.)

Although poetry taken as a whole may be classified as a holistic form of written language by virtue of its use of imagery and metaphor, poetry of a more analytical nature exists (Beaty & Matchett, 1965). This poetry is a statement of abstract ideas and has a relatively greater amount of logic structure. Such poetry may be concluded by emphasizing a specific image and/or metaphor; however, the imagery and metaphor aid in concluding an argument, and other images and metaphors in the poem are consciously played down and kept subordinate to a central argument. Poetry thus parametrized constitutes a relatively analytical and logical form of written language according to Dunn et al. (1981). This form of poetry will be referred to here as argumentative poetry. The reader should note that argumentative poetry is not synonymous with expository text. Due to lack of research on the subject it is not known whether all poetry, both descriptive and argumentative, can also be categorized as holistic and analytic prose respectively. Furthermore, the terms "descriptive" and "argumentative" are not intended to be accurate descriptors of poetry in the literary sense. These terms are strictly used to

differentiate various forms of poetry on an analytic continuum without confusing the reader when juxtaposing the terms analytic and holistic processors (descriptors of cognitive style) with analytic and holistic forms of written poetry.

## Hypotheses

The following predictions were made in regard to analytic and holistic processors' encoding and recall of argumentative and descriptive poetry. These predictions follow directly from Dunn (in press) and Dunn et al. (1981). It was hypothesized that, when given descriptive poetry (imagery and metaphor central to the theme; argument secondary to the theme), holistic processors would produce greater amounts of cortical activity in the alpha bandwidth (8-13 Hz) and recall more superordinate metaphor relative to analytic processors. It was also expected that, when given argumentative poetry (argument central to the theme; imagery and metaphor secondary to the theme), analytic processors would produce less brain activity in the alpha bandwidth and recall more superordinate metaphors relative to holistics.

In order to determine the appropriate type of EEG record to be used in researching bimodal processing, all cortical activity was measured using both monopolar and bipolar recordings. Furthermore, since the results of Dunn et al. (1981) and other prose research (Dunn & McConkie, 1972; Frederiksen, 1975a, 1975b)

suggest posible sex differences in bimodal processing, sex of participant was included as an independent variable in the present study.

## Method

### Subjects

Twenty, right handed, upper level college student volunteers (10 female and 10 male) from The University of West Florida served as participants. The subjects were paid for their participation. The mean age of female participants was 28.3 years (age range: 21-38 years). The mean age of male participants was 27.3 years (age range: 18-37 years). Handedness was determined using the Laterality Assessment Inventory (Sherman, Kulhavy & Bretzing, 1976). Past research suggests that right handed individuals exhibit more consistent hemisphere differentiation relative to left handers and ambidexters (see Herron, 1980, Chapter 9 for a review).

### Instrumentation and Apparatus

Cortical EEG was amplified by four Grass, Model P511J High Performance AC Preamplifiers. Amplified brain activity was recorded on Maxell 35-90 sound recording tape using a four channel Tandberg Series 100 Instrumentation FM recorder. The preamplifiers and recorder were periodically calibrated by inputting a 0.50 V, 10 Hz AC signal into the preamplifiers. EEG

recordings were separated into conventional frequency bandwidths using a Hewlett-Packard 5451 Fourier analysis computer. Both relative and total power EEG recordings in the alpha bandwidth (8-13 Hz) were used as dependent measures of cortical activity. Fourier transformation yields a measure of EEG "total power" (actually a squared voltage) that is a function of frequency collapsed across time. Relative EEG power was also collected. Relative EEG is a proportional score which represents a measure of the contribution of a specific EEG bandwidth or frequency to the entire power spectra recorded over a period of time.

Physiological Recording and Procedures

A nylon electrode holding cap was centered on the subject's head. Placements on the cap correlated with the International 10-20 System (Jasper, 1958). Beckman sponge-cap electrodes were placed at Cz, $P_3/T_3$ (a site midway between $P_3$ and $T_3$) and $P_4/T_4$ (a homologous site on the right hemisphere). Site $P_3/T_3$ is located over Wernicke's area which appears to be an important area for semantic processing (Geshwind, 1972; Kalat, 1980). Linked silver-silver chloride electrodes were attached to the participants' ears.

Recordings from sites $P_3/T_3$ and $P_4/T_4$ were amplified in four specific ways: $P_3/T_3$ referenced to linked ears (a monopolar recording); $P_3/T_3$ referenced to Cz (a bipolar recording); $P_4/T_4$

referenced to linked ears; and $P_4/T_4$ referenced to Cz. This created both monopolar and bipolar recordings for Wernicke's area and the homologous area of the right hemisphere. Electrode impedance was checked to ensure good electrode-to-scalp contact. Impedances of 10K ohms or less were accepted.

After electrode placement the participant was seated in a sound attenuated, electrically shielded room and asked to relax and remain silent for 10 minutes. EEG recorded during the last three minutes of this period constituted resting baseline cortical activity. Following the method outlined by Dunn et al. (1981), participants were dichotomized into analytic and holistic processors based on bilateral alpha production recorded during baseline. Holistic participants were defined as those whose average bilateral alpha production exceeded the median baseline alpha production of the whole group. Analytics were defined as those whose average bilateral alpha production fell below the median baseline alpha production of the whole group.

Participants read two poetry passages (descriptive and argumentative) which are described in detail later. Each of the eight stanzas and the titles of both poems were projected onto a screen directly in front of the participant. Participants controlled the rate of slide presentations with a hand held advance button. Subjects were allowed to view each slide once at

their own pace. Reading time was recorded for each slide presentation. Since the major variables of concern are EEG and recall, the reading time data are not presented.

After reading each poem, participants were asked to write down as much of the poetry passage as possible in any order they wished. No time limit was imposed during recall. EEG was recorded during the reading of each slide.

Poetry Passage Selection

A concise statement regarding poetry passage selection will be presented. (The reader is referred to Reddix, 1983, for complete methodological details.) The experimenter selected three descriptive/argumentative poetry pairs. None of the selections contained rhyme sequences. Three paid, independent raters (graduate English majors) scored the selections for the following: (a) imagery content, (b) imagery centrality (was the image central to the theme and denouement of the poem), (c) metaphor content, (d) metaphor centrality (was the use of metaphor central to the theme and denouement of the poem), (e) argument centrality (was an argument central to the theme and denouement of the poem relative to imagery and metaphor centrality), (f) logical structure, (g) concrete word use, and (h) abstract word use. Raters were given complete definitions of these eight terms as detailed in Reddix (1983). Raters were also

given definitions of emotional appeal, logical structure, concrete word use, and abstract word use that were identical to those found in the introduction of this study.

Descriptive poetry was defined as follows: (a) high use of metaphor and imagery, (b) the use of metaphor and imagery in such a manner that they are central to the theme and denouement of the poem, (c) high emotional appeal, (d) greater use of concrete words relative to abstract words, and (e) a low level of logical structure. Argumentative poetry was defined as the converse, that is: (a) argument central to the theme; metaphor and imagery secondary, (b) relatively less emotional appeal, (c) greater use of abstract words as compared to concrete words and/or less use of noun modifiers (adjectives), and (d) an obvious logical structure or a relatively greater logical structure.

A Likert type scale was developed in which high scores correlated with descriptive poetry characteristics and low scores correlated with argumentative poetry characteristics. It is important to note that these scores represent relative measures since the raters viewed all six poetry selections prior to assessment. A total score was derived for each poem. The absolute difference between scores was computed for each poetry pair. The pair with the greatest absolute difference was chosen as stimulus material. The descriptive and argumentative poetry selections

chosen were, "Seals, Terns, Time" (see Table 1), and "The Horse Chestnut Tree" (see Table 2), both of which were written by Richard Eberhart (cited in Brown & Milstead, 1968, pp. 132 and 401, respectively).

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Insert Tables 1 and 2 about here

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Metaphor Recall Structure

It will be helpful to review a technically complete definition of metaphor before detailing the metric for scoring subjects' recalls of metaphor from both experimental poems. Simpson (1972) thoroughly defined metaphor as follows:

> An implied comparison, omitting explicit words of comparison such as "like," "as," "as if," and "than." A metaphor is more compressed than a simile, because it identifies two things with each other or substitutes one for the other: "My love is a rose. . . ." A submerged metaphor implies, rather than states, one of the two subjects: "my winged heart" implies that "my heart is a bird." In a mixed metaphor, the comparison is strikingly disparate: "to take arms against a sea of troubles. . . ."

> Tenor and vehicle are terms used by I. A. Richards to explain the process of metaphor. If we take the sentence "My love is a rose," the principal subject "my love" would be called the tenor . . . and the secondary subject "rose" would be called the vehicle. (p. 434)

For the purposes of this study a simile will also be considered a form of metaphor. A simile is a comparison between two unlike things using as, as if, like, or than. One could say that a simile is a literal metaphor. Consider the following example: Her cheeks were like roses. The metaphorical relationship is cued by the word like. The reader need not make an inference to locate or understand the meaning of the relationship between the two dissimilar words, cheeks and roses. That relationship is clearly spelled out.

Another metaphorical relationship may be considered as a literal statement of comparison (literal metaphor) by virtue of its common and/or repeated use in everyday language. Literal metaphors may also be found in sentence structures that restrict the possible number of comparative statements in the sentence to one. An example of the former follows: "I was once such a young sprout myself" (Eberhart, cited in Brown & Milstead, 1968, p. 402). The reader immediately knows that the author of the latter phrase is not comparing himself to some form of vegetation, but

rather to an individual who has not yet reached physical maturity, probably a young child.

An example of a literal metaphor that is accomplished by restricting the number of comparisons in a sentence to one is found in this phrase: "And . . . we, outlaws on God's property" (Eberhart, cited in Brown & Milstead, 1968, p. 402). Here the author compares all of us to outlaws. No viable alternative comparisons are suggested.

In summary, a literal metaphor is characterized by figurative language that makes comparisons of unlike things by utilizing (a) simile, which makes use of the cues; as, as if, like, and than to implicitly state a comparison in which the nature of the relationship between two or more things is assumed to be understood to be of one specific form, (b) common and/or repeated statements of comparison, and (c) the use of sentence structure that, although not specifically stating a comparison, creates the antecedents for a comparison and leaves the reader with only one viable conclusion.

A second type of metaphor requires inferential reasoning. The antecedent groundwork is laid in one sentence or phrase; however, a metaphorical relationship is only made possible by comparing previously read information with subsequently read material containing no literal cues. The reader must infer the

proper metaphorical relationship. This is an inferential metaphor.

Inferential metaphors can occur separately in either the micro structure (that part of a poem that proceeds the gist or denouement) or the macro structure (that part of the poem that contains the gist or denouement) of a poem. For example, in the poem "Seals, Terns, Time" (Table 1) the author compares (metaphorically) "animal soft bonds" to "pre-history" (see Figure 1). Notice that this inferential metaphor occurred separately in the micro structure of the poem.

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Insert Figure 1 about here

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If information required to construct an appropriate metaphorical relationship is dependent upon material in both the micro and macro structure of a poem, a superordinate metaphor is created. Superordinate metaphors (if contained in a poem) are critical to a complete understanding of the gist or denouement.

Two levels of superordinate metaphors were distinguished for scoring purposes, and are shown in Figure 1. If the tenor of an inferential metaphor (one that occurs separately in either the micro or macro structure of the poem) is compared to an element (which now becomes the vehicle) in the opposing structure, a

Level I superordinate metaphor is created. In the poem "Seals, Terns, Time," "animal soft bonds" (tenor of an inferential metaphor in the micro structure) is related to "mammal water" (element in the macro structure). Refer to Figure 1 for an example of a Level I superordinate metaphor.

If the vehicle of an inferential metaphor (one that occurs separately in either the micro or macro structure of the poem) is compared to an element (which now becomes the vehicle) in the opposing structure, a Level II superordinate metaphor is created. For example, in the poem "Seals, Terns, Time" (see Table 1) "pre-history" (the vehicle of an inferential metaphor in the micro structure) is compared to "mammal water" (an element in the macro structure). Refer to Figure 1 for an example of a Level II superordinate metaphor.

A review of inferential and superordinate metaphors will be helpful at this point. Refer to Figure 1 following each example. The following inferential metaphor was created in the micro structure of the poem, "Seals, Terns, Time": animal soft bonds (tenor) is compared to pre-history (vehicle). If animal soft bonds is now compared to mammal water (element in the macro structure), a Level I superordinate metaphor is created in which a higher order inferential link (pre-history) is excluded. Animal soft bonds is now the tenor of the Level I superordinate metaphor

and mammal water is the vehicle. If pre-history (vehicle in the micro structure of an inferential metaphor) is compared to mammal water (element in the macro structure), a Level II superordinate metaphor is created in which the use of a higher order inferential link (pre-history) is included. Pre-history is now the tenor of the Level II superordinate metaphor and mammal water is the vehicle.

A Level II superordinate metaphor tends to be allegorical in nature. It is "an extended metaphor, with subordinate metaphors depending from the main" (Simpson, 1972, p. 404). It is important to note, however, that a Level II superordinate metaphor may also be created if an element of the micro structure (one that does not occur in an inferential metaphor) is compared to an element in the macro structure.

If the four types of metaphors described here (literal, inferential, Level I superordinate, and Level II superordinate) were ranked in order of complexity and their contribution to a complete understanding of the denouement of a poetic work, Level II superordinate metaphors would be ranked Number one (most important, most complex), Level I superordinate metaphors would be ranked Number two, inferential metaphors would be ranked Number three, and literal metaphors would be ranked Number four (least important, least complex). Complete metaphor recall

structures for both poems can be found in the appendix. Scoring is self-explanatory and based on the preceding discussion.

General Design

Due to the complex nature of this investigation, a brief overview of the experimental design will be presented. The dependent measures used in this study were electroencephalographic alpha production and proportional recall. Five independent variables were analyzed with respect to their effect on EEG alpha production during reading and encoding of poetry. They were: (a) cognitive style (analytic and holistic), (b) gender (male and female), (c) poem (argumentative and descriptive), (d) hemisphere (left and right), and (e) slide (1-8). This yielded the following 5-way mixed analysis of variance: 2 (cognitive style) by 2 (gender) by 2 (poem) by 2 (hemisphere) by 8 (slide). Slide was included for two purposes. First, since the proportion of metaphor varies with each slide, it might be expected that "slide viewed" might affect alpha production. Such a measure would account for variability at a more molar level in the event that the "levels of metaphor" analysis failed. Secondly, slide was included as an independent variable as a check for possible differential effects of viewing time on alpha production.

Four independent variables were analyzed with respect to their effect on proportional recall of metaphors. They were: (a) cognitive style, (b) gender, (c) poem, and (d) level of information recalled (four levels of metaphors). The latter yielded a 2 (cognitive style) by 2 (gender) by 2 (poem) by 4 (level) mixed analysis of variance for metaphor recall.

## Results and Discussion

Since this study involves several different sets of data analyses, an overview will be helpful. Generally, the analyses fall into two areas: EEG measures as a dependent variable of cortical activity at encoding, and proportional recall as a dependent measure of information retrieval. With regard to EEG analyses, both total and relative power EEG were referenced to Cz and linked ears, creating four separate data analyses (e.g., total power--Cz, relative power--Cz, total power--linked ears, and relative power--linked ears). Within proportional recall, metaphor data were analyzed separately using the four EEG conditions just discussed for processor dichotomization. This created four separate analyses for metaphor recall. A brief discussion of the statistical designs used, along with a review of other pertinent information, precedes both EEG and proportional recall analyses.

Reading EEG Alpha Production During Acquisition and Encoding of Argumentative and Descriptive Poems

Four, 5-way ANOVAs were conducted. Each utilized the same independent variables. This resulted in a 2 (cognitive style: analytic/holistic) by 2 (gender: male/female) by 2 (poem: argumentative/descriptive) by 2 (hemisphere: left/right) by 8 (slide: eight per poem) mixed analysis of variance with repeated measures on the last three variables. Each ANOVA used different combinations of EEG alpha production (total or relative) and reference site (Cz or linked ears) to acquire dependent measures of alpha production during acquisition and encoding (see Table 3).

The reader should note that dichotomization into analytic or holistic processors was based on EEG baseline alpha production corresponding to the type of EEG data used in each specific ANOVA. For example, ANOVA 1 used total alpha production referenced to Cz for processor dichotomization.

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Insert Table 3 about here

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Due to a lack of differential alpha production between hemispheres during resting baseline recordings, participant dichotomization was determined using average alpha production

(left hemisphere + right hemisphere / 2). Table 4 lists correlations between hemispheres for all--alpha production/reference site--baseline recordings.

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Insert Table 4 about here

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Reading EEG: total alpha production referenced to Cz. The main effect of cognitive style was statistically significant, $F(1,16) = 10.31$, $p < .0055$, indicating that holistic procesors produce more mean alpha ($M_H = .007230$, SD = .005810) than do analytic procesors ($M_A = .002693$, SD = .001899). Similar main effects have been reported by Dunn et al. (1981) who used identical dependent measures and recording sites. They found that holistics produced significantly more mean bilateral alpha than analytics when reading any of three expository passages, each varying in semantic structure.

The main effect of poem was also significant, $F(1,16) = 4.85$, $p < .0427$, and indicated that subjects as a whole produced more mean alpha when reading the descriptive poem, "Seals, Terns, Time" ($M = .005143$, $SD = .004918$), than when reading the argumentative poem, "The Horse Chestnut Tree" ($M = .004727$, SD = .004826). Dunn et al. (1981) also found that significantly less

bilateral alpha was produced across subjects during the reading of the most semantically structured of three passages.

The three-way interaction of poem by cognitive style by hemisphere, reached statistical significance, $F(1,16) = 4.55$, $p < .0488$, and is shown in Table 5.

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Insert Table 5 about here

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Post hoc testing (Scheffe, $p < .05$) yielded two interesting results. First, the mean left and right hemisphere alpha production of analytics, during reading, was always significantly lower than the mean left and right hemisphere alpha production of holistics. This was true for both argumentative and descriptive poetry passages. Secondly, holistic processors produced significantly greater mean alpha in their right hemisphere than they did in their left hemisphere during the reading of the descriptive poem. No significant hemispheric differences were found for analytic processors as a group. The reader should note, however, that the right hemisphere of both processors generated more mean alpha (although not always significantly more) than did the left hemisphere regardless of the poem being read.

The observation that the right hemisphere generates more mean alpha than the left, particularly while encoding the descriptive poem, supports the findings of Doyle, Ornstein, and Galin (1974). They found (using right/left hemisphere ratios) that temporally recorded alpha increases in the right hemisphere during verbal processing (written letter, mental letter, verbal listening) as compared to performing arithmetic tasks (visual, motor, and serial arithmetic). These results are contrary, however, to recent research findings (Dunn et al., 1981) in which identical P/T recordings showed left hemisphere alpha production greater than right hemisphere alpha production for verbal performance tasks. These observed differences may be due to the types of reading material used in each study. For example, Dunn et al. (1981) used expository text (a tightly structured form of text), whereas, poetry (a less tightly structured form of reading material) was utilized in the present study.

Research by Ehrlichman and Wiener (1979) supports the idea that various mental tasks differentially affect alpha production. They found greater alpha production in the left hemisphere for covert mental tasks involving: multiplication, letter/speech skills, finger counting, verbal counting, and verbal long-term memory (more analytic tasks). Conversely, greater right hemisphere alpha production was found during covert mental

processes involving: music without words, visual kinesthetic imagery, visual long-term memory, body feelings, and visual counting (more holistic tasks). From this it would logically follow that right hemisphere alpha production would be greater than left during the mental processing of descriptive poetry since imagery and metaphor were central to its theme.

Reading EEG: total alpha production referenced to linked ears. Linked ears referenced alpha generation yielded no significant main effects or interactions. The reader should note that recent researchers (Linnville, 1983, and Rust, 1982) have drawn their most interesting statistical inferences related to cognitive style differences during reading with linked ears referenced alpha production. However, these researchers used expository text, not poetry, as stimuli.

Reading EEG: relative alpha production. The five-way ANOVA that utilized relative power alpha referenced to Cz yielded one significant main effect of no major interest, i.e., slide $F(7,112) = 3.30$, $p < .0032$.

Relative alpha referenced to linked ears yielded a significant main effect of cognitive style, $F(1,16) = 5.30$, $p < .0351$, which supports the previously reported main effect of cognitive style that utilized total alpha production referenced to Cz as a dependent measure. Specifically, holistics produced

more mean alpha when reading (M = .19795, SD = .08178) than did analytics (M = .14359, SD = .04609). Relative power alpha generation referenced to linked ears produced significant three-way and four-way interactions. They were: gender by slide by hemisphere, $F(7,112) = 2.83$, $p < .0094$, and poem by cognitive style by gender by slide, $F(7,112) = 2.50$, $p < .0202$, respectively. Due to the complexity of these interactions it was not clear which factors were primarily responsible for the observed variability of alpha production.[1]

Proportional Metaphor Recall

As detailed earlier, proportional recall scores were derived for each of the four levels of metaphor. Interrater reliability measures were established. Twenty-five percent of the metaphor protocols for both poems were scored by one of the experimenters and an independent rater. An interrater reliability measure of 95% (expressed as percent agreement) was obtained for metaphor scoring. Experimenter scored protocols were used in subsequent analyses.

Proportional metaphor recall protocols were analyzed separately using a four-way mixed analysis of variance. The independent variables were cognitive style, gender, poem, and level. Poem and level were repeated measures. As previously mentioned, participants were dichotomized as analytic or holistic

processors based on four different types of--alpha production/reference site--baseline recordings (see Table 3). Consequently, four different analyses were run for metaphor recall.

Theoretically, proportional data form binomial rather than normal distributions, especially with small or large proportions (Zar, 1974, p. 185). Since many of the proportional recall scores for both metaphor and imagery fell in the 0 to 30 percent and the 70 to 100 percent range of possible scores, arcsine transformations were performed on the data. Subsequent analyses utilizing arcsine transformed data will be reported in this paper. The reader should note, however, that non transformed data did yield equivalent significant results. All post hoc testing was done with Scheffe's Multiple Contrasts (Zar, 1974) at the .05 probability level. Only pairwise comparisons among means were statistically tested.

Before looking at specific analyses, it is important to note that any significant main effect of level or poem will naturally repeat itself in subsequent analyses. The main and interaction effects of cognitive style and gender change as a function of processor dichotomizations whereas the main effects of level and passage do not. In other words, if the main effect of level of metaphor is significant in the proportional recall analysis using

total alpha production referenced to Cz for processor dichotomization, then it will also be significant in the following three analyses. Consequently, the means and standard deviations will only be reported for the first occurrence since they will remain the same for succeeding analyses. Finally, scoring of metaphor recall revealed that only two subjects (one analytic and one holistic) recalled Level II superordinate metaphors. Consequently, proportional recall scores for Level I and Level II superordinate metaphors were combined to form one level of superordinate metaphor recall.

Proportional metaphor recall: total alpha, Cz dichotomization. The only main effect to reach statistical significance was level, $F(2,32) = 12.29$, $p < .0001$. Post hoc testing confirmed that the mean proportional recall of Level two information ($M_2 = .26566$, $SD = .06247$) was significantly greater than the recall of Level one and Level three information ($M_1 = .10095$, $SD = .03016$; $M_3 = .07861$, $SD = .03384$). In other words, significantly more inferential metaphors were recalled relative to superordinate and literal metaphors.

The three-way interaction of poem by cognitive style by gender reached statistical significance, $F(1,16 = 12.18$, $p < .003$. Post hoc testing showed that the mean proportional recall of male holistics ($M = .30035$, $SD = .10243$) was significantly

greater than that of male analytics (M = .03737, SD = .01183) for descriptive poetry. Although no other significant simple effects were observed for this interaction, the reader should note the differential recall pattern of males and females. Figure 2 represents this interaction as two, 2-way components of the three-way interaction.

---

Insert Figure 2 about here

---

Female analytics recalled more metaphors from the descriptive poem than did male analytics, whereas male analytics recalled more metaphors from the argumentative poem than did female analytics. Male and female holistics show the inverse pattern of recall. Specifically, males recalled more metaphors from the descriptive poem than did females, and females recalled more metaphors from the argumentative poem than did males. This observation is most pronounced for analytics' and holistics' recall of metaphor from the descriptive poem. An interpretation of this interaction in terms of bimodal theory is presented later.

Proportional metaphor recall: total alpha, linked ears dichotomization. As expected, the main effect of level was statistically significant, $F(2,32) = 9.67$, $p < .0005$.

Surprisingly, no significant interactions were observed when using this particular processor dichotomization.

Proportional metaphor recall: relative alpha, Cz and linked ears dichotomizations. Cognitive style dichotomizations were equivalent (i.e., the same subjects were grouped into analytic and holistic categories) when using relative power alpha production referenced to Cz or linked ears. Consequently, separate analyses yielded the same significant main effects and interactions. The main effect of level was significant, $F(2,32) = 10.09$, $p < .0004$.

The three-way poem by cognitive style by gender interaction reached statistical significance, $F(1,16) = 4.95$, $p < .0409$. Conservative Sheffe post hoc tests showed no significant differences between the means; however, the differential recall pattern (male and female analytics versus male and female holistics) was similar to that found earlier.

Summary of Results

Given the complexity and scope of the above analyses, the following summary is presented. Analyses that used the EEG as a dependent measure will be reviewed first. The main effect of cognitive style was significant for EEG analyses using total alpha referenced to Cz and relative alpha referenced to linked ears, indicating that holistics produced more mean alpha than did

analytics when reading poetry. Alpha production referenced to Cz also yielded the significant main effect of poem, indicating greater alpha production across subjects while reading the descriptive poem. The main effect of slide was significant for the relative-alpha/Cz-reference analysis.

Total alpha production referenced to Cz provided the significant three-way interaction of poem by cognitive style by hemisphere. This interaction yielded differences in the direction that would be predicted by bimodal theory. Finally, relative alpha referenced to linked ears yielded significant, albeit less interesting and interpretable, gender by slide by hemisphere and poem by cognitive style by gender by slide interactions.

Proportional metaphor recall data provided a wealth of information in the form of significant main effects and interactions. The main effect of level was significant for all metaphor analyses and indicated that more inferential metaphors were recalled relative to other levels of metaphors. The significant poem by cognitive style by gender interaction was similar when either total-power/Cz-reference or relative-power/linked-ears referenced processor dichotomizations were used. These interactions clearly demonstrated differential recall for cognitive style and gender.

## Conclusions and Implications

### Recall

The proposed holistic dimension of bimodal theory (Dunn, in press; Dunn et al., 1981) is partially supported by results of proportional metaphor recall data. Males followed the predicted patterns for holistic and analytic recall of metaphors, with holistic males consistently recalling more metaphors from descriptive poetry. The converse was observed for analytic males who recalled less of the descriptive poem relative to the argumentative poem (the less holistic poem).

Female holistics and analytics showed consistent proportional metaphor recall patterns which were opposite to those predicted, thus opposite that of holistic and analytic males. Specifically, female holistics tended to recall more metaphors from the argumentative poem relative to the descriptive poem and female analytics generally recalled more metaphors from the descriptive poem relative to the argumentative poem. This suggests that the alpha measurements used to dichotomize subjects into analytic and holistic processors are inversely related for male and female subjects. That is, female holistics should be defined as those who produce less than median alpha, whereas male holistics are those who produce greater than median alpha for the group. Analytics would follow the opposite pattern with females'

alpha being above the median alpha and males' median being below the median production for the group. Although problematical, others have found sex differences using similar tests and procedures using expository text (Dunn et al. 1981). These differences, however, were not as clear as here using poetry. Given recent research in neurophysiology and psychobiology suggesting that the male and female brains can produce different EEG activity and may be organized differently (e.g., Witelson, 1976), our somewhat surprising results may have a physiological basis. Clearly, further research is needed in this area using different cognitive tasks and recording sites to establish the nature of these gender diferences. The reader should note that differences in proportional metaphor recall discussed here were probably due to subjects' recall of inferential metaphors since recall of other levels of metaphor were predominantly low.

The results of metaphor recall indicate that the metaphor scoring structure developed for poetry in the present study provided a metric for components not addressed in other text analysis systems. For example, text analysis systems developed by Kintsch et al. (1975) and Meyer (1975) do not address metaphor as part of their analyses.

EEG Alpha Production

Although alpha production did not reflect the gender differences observed in recall, it still supports the existence of the holistic dimension of bimodal processing. Bipolar EEG recordings referenced to Cz provided the most interesting and interpretable results, with regard to alpha production during encoding of descriptive and argumentative poetry. As expected, the total power alpha production of holistics was greater than that of analytics during the encoding of either poetry selection. Also, participants had greater alpha production while reading and encoding descriptive poetry as compared to their alpha production during reading and encoding of argumentative poetry.

EEG alpha production appears to be a generally reliable correlate of cognitive style differences. The trend of right and left hemisphere baseline alpha production of holistics being greater than that of analytics is consistently observed during encoding of both poetry passages. If one considers the argumentative poem to be the most logically structured of the two passages used in this study, then this result parallels the finding of Dunn et al. (1981) who utilized various levels of expository text and identical P/T recording sites.

It is important to note at this point that alpha production was not sensitive to the differential recall (cognitive style by gender) observed in this study. An astute reader may, at first, question the reliability of the recall measures in this regard. The consistency of the differential recall reported for males and females, in addition to the obvious support for bimodal theory shown by males, should weaken such an argument. Instead, we believe that viewing alpha production in isolation, rather than in conjunction with other frequencies of cortical activity, may account for the lack of correlation between differential recall (cognitive style by gender) and brain activity. Interestingly, only relative alpha production yielded significant EEG interactions that included gender and cognitive style. Such a result may be indicative of frequency shifts related to these variables. Future research may find it useful to correlate simultaneous shifts in various EEG bandwidths with recall measures. For example, high and low frequency shifts (alpha and/or theta versus beta) observed during encoding may be more sensitive to both cognitive style and gender differences. The simple point is that alpha should probably be viewed in conjunction with other frequency measures of cortical activity in order to investigate accurately bimodal theory in light of differential recall.

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Appendix

Metaphor Recall Structure

"Seals, Terns, Time"

| Line | Literal Metaphor | Inferential Metaphor | L.M. | I.M. |
|---|---|---|---|---|
| 1 | MICRO STRUCTURE<br>Seals ← Animal Soft Bonds (11)<br>Seals ← Ancient Blood (8)<br>Seals ← Blurred Kind Forms (8) | | | |
| 4 | Sea Elemental Water | | | |
| 11<br>9 | Animal Soft Bonds (Seals) → Prehistory (12)<br>Elemental Water (Sea) → (man's past) | | | |
| 5<br>6<br>7 | . . . curious images,<br>Hypnotic, sympathetic eyes<br>As the deep elapses of the soul. | | | |
| 16 | Their aspirations dip in mine, | | | |

"Seals, Terns, Time"

| Line | Literal Metaphor | Inferential Metaphor | L.M. | I.M. |
|---|---|---|---|---|
| | MICRO STRUCTURE | -- | | X |
| 18 | More freedom than the eye can see. | | | |
| 14 | Fork-tailed Terns ⟶ | Freedom (18) (man's future) | X | |
| | MACRO STRUCTURE | | | X |
| | (1pt.) (1pt.) | | | |
| 21 | (I am) A/ (We are) gauze and spin- drift of the world, | | | |
| | | Raw Score | | |
| | | Total Possible | 9 | 3 |
| | | Proportional Score | | |

"Seals, Terns, Time"

| Line | Precursor | Inference | Level I | Level II |
|---|---|---|---|---|
| | LEVEL I | | | |
| 9 & 4 | Elemental Water and/or Sea | Mammal Water (23) | | |
| 11 & 1 | Animal Soft Bonds and/or Seals | (man's beginning) | | |
| 14 | Fork-tailed Terns | Sky (24) | | |
| | LEVEL II | | | |
| 12 | Prehistory | Mammal Water (23) (man's beginning) | | |
| 24 | Sky | Freedom (18) (man's future) | | |

"Seals, Terns, Time"

| Line | Precursor | Inference | Level I | Level II |
|---|---|---|---|---|
| | ) | Raw Score | | |
| | | Total Possible | 3 | 2 |
| | | Proportional Score | | |

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Proportional Score Breakdowns

| Literal Metaphor | Inferential Metaphor | Level I Sup. Ord. | Level II Sup. Ord. |
|---|---|---|---|
| | | | |
| $L_4$ | $L_3$ | $L_2$ | $L_1$ |

"The Horse Chestnut Tree"

| Line | Literal Metaphor | Inferential Metaphor | L.M. | I.M. |
|---|---|---|---|---|
| | MICRO STRUCTURE | | | |
| 1 | Boys in sporadic but tenacious droves → | their (boys) lawlessness (4). | X | |
| 2 | (Boys) come with sticks as certainly as Autumn, | | | X |
| 5 | Shining Amulet → | Chestnut(s). (11) | X | |
| 17 | Prize and trophy → | | | |
| 16 | I was once such a young sprout myself. | | | X |
| 4 | their (boys) lawlessness. → | I was once such a young sprout myself. (16) | X | |

"The Horse Chestnut Tree"

| Line | Literal Metaphor | Inferential Metaphor | L.M. | I.M. |
|---|---|---|---|---|
| | MACRO STRUCTURE | | | |
| 19 | (I) we, outlaws | | | |
| 19 | God's property, ⟶ | Great flowering world (23) | | |
| | | Raw Score | | |
| | | Total Possible | 5 | 3 |
| | | Proportional Score | | |

"The Horse Chestnut Tree"

| Line | Precursor | Inference | Level I | Level II |
|---|---|---|---|---|
| | LEVEL I | | | |
| 4 | their (boys) lawlessness. | (I) we, outlaws (19) | | |
| 5 | Shining Amulet | Tangible good (21) | | |
| 17 | Prize & trophy | | | |
| 19 | God's property | Great horse chestnut tree. (3) | | |
| | LEVEL II | | | |
| 16 | I was once such a young sprout myself. | (I) we, outlaws (19) | | |
| 20 | Fling out imagination beyond the sky. | With shrill arms they fling . . . (8) | | |
| 11 | Chestnuts | Tangible good (21) | | |
| 22 | Death | Lawgiver (15) or Evening | | |

"The Horse Chestnut Tree"

| Line | Precursor | Inference | Level I | Level II |
|---|---|---|---|---|
| | LEVEL II | | | |
| 22 | And likewise death will drive us from the scene. | . . . I . . . chase the boys away: (13-14) | | |
| 23 | Great flowering world | Great horse chestnut tree. (3) | | |
| 24 | Which we held in idea, a little handful. | Held life like we held chestnuts. | | |
| | | Raw Score | | |
| | | Total Possible | 4 | 7 |
| | | Proportional Score | | |

********

| Literal Metaphor | Inferential Metaphor | Level I Sup. Ord. | Level II Sup. Ord. |
|---|---|---|---|
| | | | |
| $L_4$ | $L_3$ | $L_2$ | $L_1$ |

## Footnotes

This research was funded in part by the Educational Research and Development Center at The University of West Florida.

[1]Means and Standard Deviations for all analyses can be obtained from Mike Reddix, Center for the Study of Reading, University of Illinois, Champaign, Illinois.

Table 1

"Seals, Terns, Time"

| Structure | Stanza |
|---|---|
| | The seals at play off Western Isle |
| micro | In the loose flowing of the summer tide |
| | And burden of our strange estate- |
| | Resting on the oar and lolling on the sea; |
| micro | I saw their curious images, |
| | Hypnotic, sympathetic eyes |
| | As the deep elapses of the soul. |
| micro | O ancient blood, O blurred kind forms |
| | That rise and peer from elemental water: |
| | I loll upon the oar, I think upon the day, |
| micro | Drawn by strong, by the animal soft bonds |
| | Back to a dim pre-history; |
| | While off the point of Jagged Light |
| micro | In hundreds, gracefully, the fork-tailed terns |
| | Draw swift esprit across the sky. |

Table continues

| Structure | Stanza |
|---|---|
| | Their aspirations dip in mine, |
| micro | The quick order of their changing spirit, |
| | More freedom than the eye can see. |
| | Resting lightly on the oarlocks, |
| macro | Pondering, and balanced on the sea, |
| | A gauze and spindrift of the world, |
| | I am in compulsion hid and thwarted, |
| macro | Pulled back in the mammal water, |
| | Enticed to the release of the sky. |

Note. Author: Richard Eberhart (cited in Brown & Milstead, 1968, p. 132).

Table 2

"The Horse Chestnut Tree"

| Structure | Stanza |
|---|---|
| | Boys in sporadic but tenacious droves |
| micro | Come with sticks, as certainly as Autumn, |
| | To assault the great horse chestnut tree. |
| | There is a law governs their lawlessness. |
| micro | Desire is in them for a shining amulet |
| | And the best are those that are highest up. |
| | They will not pick them easily from the ground. |
| micro | With shrill arms they fling to the higher branches, |
| | To hurry the work of nature for their pleasure. |
| | I have seen them trooping down the street |
| micro | Their pockets stuffed with chestnuts shucked, unshucked. |
| | It is only evening keeps them from their wish. |

Table continues

| Structure | Stanza |
|---|---|
| | Sometimes I run out in a kind of rage |
| micro | To chase the boys away; I catch an arm, |
| | Maybe, and laugh to think of being the |
| | lawgiver. |
| | I was once such a young sprout myself |
| micro | And fingered in my pocket the prize and |
| | trophy. |
| | But still I moralize upon the day |
| | And see that we, outlaws on God's property, |
| macro | Fling out imagination beyond the skies, |
| | Wishing a tangible good from the unknown. |
| | And likewise death will drive us from the scene |
| macro | With the great flowering world unbroken yet, |
| | Which we held in idea, a little handful. |

Note. Author: Richard Eberhart (cited in Brown & Milstead, 1968, p. 401).

Table 3

Tables of EEG Recordings Utilized as Dependent Measures

| ANOVA | Type of EEG recording |
|---|---|
| 1 | Total alpha production (8-13 Hz) referenced to Cz. |
| 2 | Total alpha production (8-13 Hz) referenced to linked ears. |
| 3 | Relative alpha production (8-13 Hz) referenced to Cz. |
| 4 | Relative alpha production (8-13 Hz) referenced to linked ears. |

Table 4

Pearson Product-Moment Correlations of Right and Left Hemisphere Alpha Production During Resting Baseline Recordings

| | Reference site | |
|---|---|---|
| Type of Alpha | Cz | LE[a] |
| | (r) | (r) |
| Total Power | .874 | .975 |
| Relative Power | .915 | .962 |

Note. Recording sites were $P_3/T_3$ and $P_4/T_4$.

[a]Linked ears

Table 5

Mean Alpha Production Recorded During Reading as a Function of Type of Processor, Hemisphere, and Poem

| | Poem | | | |
|---|---|---|---|---|
| Type of Processor | Descriptive | | Argumentative | |
| Analytics | M | ( SD ) | M[a] | ( SD ) |
| Left hemisphere | .002654 | (.002063) | .002333 | (.001427) |
| Right hemisphere | .002859 | (.002126) | .002710 | (.003314) |
| Holistics | | | | |
| Left hemisphere | .006560 | (.004488) | .006585 | (.005743) |
| Right hemisphere | .008508 | (.006702) | .007267 | (.005981) |

[a]Means represent total alpha production referenced to Cz and expressed in arbitrary units.

## Figure Captions

Figure 1. Progressive development of metaphorical relationships in poetry.

Figure 2. Mean proportional metaphor recall as a function of poem, cognitive style, and gender; total alpha, Cz dichotomization.

[a]Means derived from arcsine transformed scores.

Figure 3. Mean proportional metaphor recall as a function of poem, cognitive style, and gender; Relative alpha, Cz and linked ears dichotomizations.

[a]Means derived from arcsine transformed scores.

STRUCTURE

| (micro) | (micro) | (macro) |
|---|---|---|
| Animal soft bonds | Pre-history | Mammal water |

---

Inferential Metaphor

(tenor) (vehicle)

Animal soft bonds ⟶ Pre-history

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Level I Superordinate Metaphor

(tenor) (vehicle)

Animal soft bonds ⟶ Mammal water

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Level II Superordinate Metaphor

(tenor) (vehicle)

Pre-history ⟶ Mammal water

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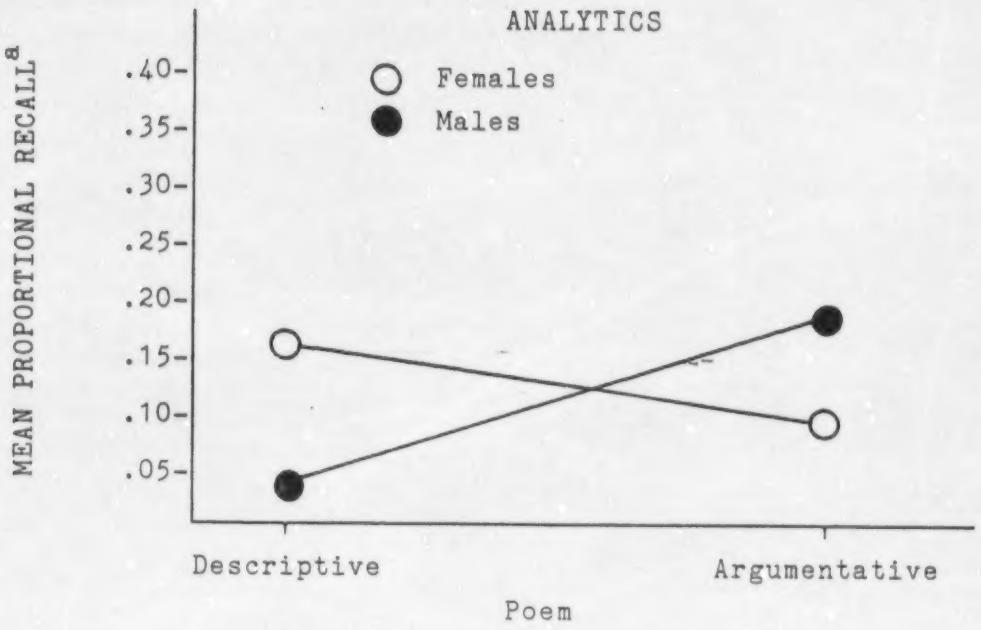
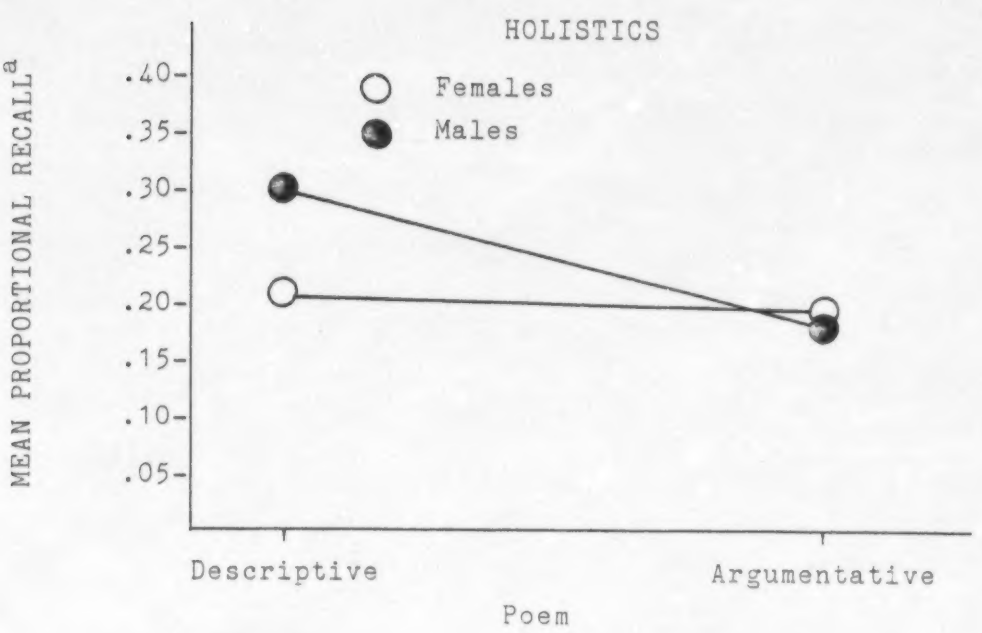

ANALYTICS
Females
Males
MEAN PROPORTIONAL RECALL[a]
.40
.35
.30
.25
.20
.15
.10
.05
Descriptive
Argumentative
Poem


HOLISTICS
Females
Males
MEAN PROPORTIONAL RECALL[a]
.40
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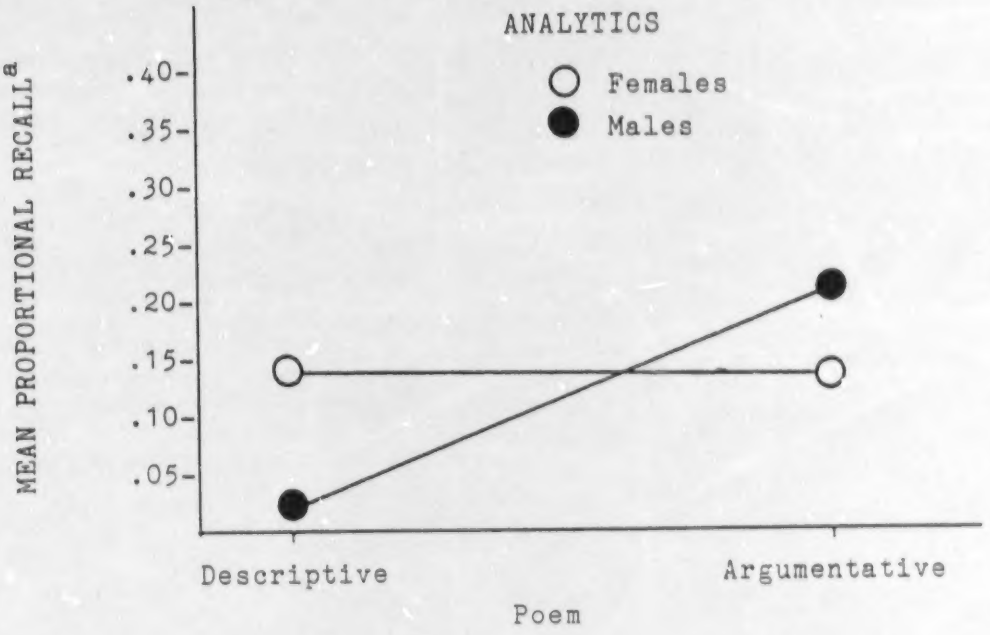
.25
.20
.15
.10
.05
Descriptive
Argumentative
Poem


ANALYTICS
Females
Males
MEAN PROPORTIONAL RECALL[a]
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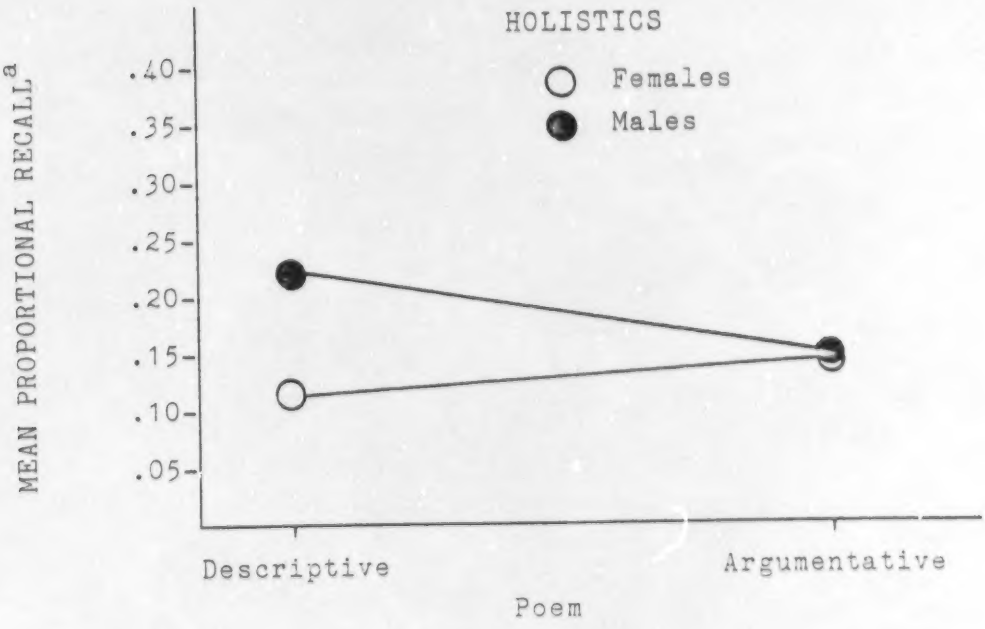
Descriptive
Argumentative
Poem


HOLISTICS
Females
Males
MEAN PROPORTIONAL RECALL[a]
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Descriptive
Argumentative
Poem